

ment less so. This peculiarity is well brought out by arranging the instrumental and personal records according to the clearness of the sky.

Photographic register.					Thermometric register.				
Sunshine.		Cloudiness.		Difference.	Sunshine.		Cloudiness.		Difference.
Instru- mental.	Per- sonal.	Instru- mental.	Per- sonal.		Instru- mental.	Per- sonal.	Instru- mental.	Per- sonal.	
82	64	18	36	18	84	60	16	40	24
81	61	19	39	20	70	61	30	39	9
75	54	25	46	21	68	54	32	46	14
66	54	34	46	12	67	42	33	58	25
66	53	34	47	13	63	56	37	44	7
56	43	45	57	13	59	45	41	55	14
54	51	46	49	3	58	45	42	55	13
51	46	49	54	5	57	50	43	50	7
50	42	50	58	8	56	43	44	57	13
47	44	53	56	3	54	41	46	59	18
45	38	55	62	7	54	36	46	64	18
42	32	58	68	10	54	37	46	63	17
39	34	61	66	5	52	46	48	54	6
38	38	62	62	0	50	50	50	50	0
23	24	77	76	1	49	40	51	60	9
					48	39	52	61	9
					48	41	52	59	7
					47	36	53	64	11
					44	41	50	59	3
					44	38	56	62	6
					35	33	65	67	2

In the above table the general monthly averages given in the last two columns of Table IV, for February, are thus rearranged separately for the thermometric and photographic re-

ord, and beside the percentages of sunshine, as there given, I have also added the complementary percentages of cloudiness.

After smoothing down the local discrepancies we see that in clear climates the observer gives the cloudiness full weight, and possibly overestimates it while the instrument may underestimate it, but for cloudiness of 60 or 70 per cent the observer and instrument agree, and probably would continue to do so very closely for the higher percentages.

There is no necessary agreement between a single instrumental register and the observer at any given station, but, in general, if many registers were closely and uniformly distributed within a few square miles near the observer and under the clouds that he records, then the average of all these registers should agree with the personal record. The practically close agreement between the average of all the personal and instrumental records at our widely-separated stations depends upon the fact that the clouds have an average motion and distribution that are very much the same everywhere, so that the percentage of duration of sunshine at any station and the percentage of geographical area that enjoys the sunshine agree closely in the monthly and annual averages, though they may differ widely on any given day or hour. The local sunshine record is undoubtedly the most important datum in the study of local agricultural or phenological questions. The average percentage of cloudiness is the most important datum for the study of the distribution of temperature and ascending currents in the atmosphere.

NOTES BY THE EDITOR.

SNOW IN NEW ENGLAND.

With regard to the question of diminished snowfall in New England, Miss Ellen D. Larned, of Thompson, Conn., says:

My records have some bearing. In addition to my own forty years' observations I have a family diary dating back to 1817, with some unfortunate lapses. These records give the date and general characteristics of snowfalls, but not usually the the depth or amount. In copying from them I omit the light falls and flurries occurring more or less from October to May, and only note snows covering the ground and definite storms.

1817.—No snow of any perceptible amount till December 21; violent north-easterly snowstorm, but not much snow; very cold.

1818.—January 10, first sleighing of the winter; about 4 inches of snow fell; very good sleighing for so little snow; snowed sharp for a few hours; sleighing continued till March 2. March 28, much of a snowstorm; good sleighing for several days. November 18, snowed large and moist; no sleighing the following winter, save a few days after a violent storm of sleet and rain.

1819.—February 25, a succession of moderate snows. Snow on March 6, 8, and 9 made good sleighing. 16th, severe storm; coldest day of winter; excellent sleighing for a week. October 25, snowed all night. November 28, snowed all night and the next day, but no sleighing. December 30, a cold, tedious snowstorm, wind very high. 31st, high cold wind, snow blows violently; poor sleighing.

1820.—January 11, a violent snowstorm. 17th, most violent snowstorm, wind very high. 22d, snowed in the morning; sleighing improved. February 9, most violent storm all day; no stirring about; greatest fall of snow this winter; roads all blocked up. 10th, heavy fall of snow in the night. 11th, snows in the morning; blows hard; roads all filled up. 12th, all hands breaking roads; a thaw follows, but not sufficient to mar the sleighing. March 4, pretty good sleighing. 8th, snow, hail, and rain violent all day. 9th, rain continues. 10th, trees very heavily laden, snow slips off without much damage. 12th, cold and clear; roads have frozen, and crust to bear up horses, sleighs, and teams. 16th, good sleighing. 17th, snows prettily. 19th, snow falls, almost all gone, but it went to return with renewed force in the autumn. November 12, Sunday, snows in the night and all day; a right wintry, cold storm; no meeting; snow about 8 inches or more on the level. 13th, very cold, snowy morning, some rain or sleet, clears off at noon; hard sleighing. 14th, break into the woods with sled and haul two loads of wood; sleighing and sledding continued through the week. This November snowstorm of 1820 was handed down to posterity as exceeding in severity anything ever before experienced by the oldest inhabitant so early in the season, and it is believed that the record in this vicinity, at least, remains unbroken.

1821.—January 7, a terrible, cold snowstorm; first sleighing. 14th, very high, rough storm of snow. 22d, snows about 4 inches in the night. Febru-

ary 6, sleighing gone. 15th, snows again; pretty good sleighing, continuing some days. November 30, snowed all day, light; high wind. December 14, first sleighing, pretty good but rough, duration doubtful.

1822.—Good sleighing reported early in February. 18th, snows all day. 21st, very rainy, high freshet. December 3, snows hard in the night; folks began to sleigh, but could not keep it up.

1823.—January 1, violent blowing storm; resumed sledding. 5th, violent storm of snow and hail. 19th, snow wastes fast; violent rain. February 3, more snow and sleighing. 12th, deep snow and very level. 14–15th, very great snowstorm; a man perished on the meadow. 24th, a violent snowstorm all day; roads terribly blocked up; all hands out to shovel. March 2, threatens to thaw. 3d, cold as Greenland and grows colder all day. 6th, violent rain and snow. 20th, snow; good sleighing.

1823–1829.—For these six years there is no record. It is during this interval that I am inclined to place a snowless term of years referred to in family reminiscences as the time when snowstorms were supposed to have permanently gone out of fashion and people talked of selling their sleighs.

1829.—November 14, snow, changing to rain. 16th, snows considerable; remarkably warm Christmas weather; twelve days all fine and warm.

1830.—January 25, term of snow. February 3, sleigh ride to Woodstock. 10th, great sleigh ride. 22d, sleighing done. March 23, snow. 26th, violent storm of snow all day. December 6, first winter snow. 19th, snow all day; good sleighing.

1831.—January 9, snow all day; no going to meeting. 15th, violent snowstorm, badly drifted; no service in church. 22d, snow all day. 23d, very cold and blowy; no sleighing nor getting about, only on foot. February 1, snow. 3d, another furious storm, some rain; sleighing continues to 25th; children taken to school on horseback. November 22, heavy snow; good sleighing continues till January 15. Coldest December ever known.

1832.—February 5, snow; sleighing till March 1. March 18, snows again. April very cold, with frequent snows to the 26th. Snow December 1 and 15.

1833.—January warm and pleasant. 25th, snow and sleighing. 31st, very hard snowstorm. February 6–7, harder storm. March 1, very severe snowstorm; could not see across the road; no such weather ever before seen in March; coldest of the season. 16th, very muddy. October 30, coldest weather ever known in October. November 4–6, winter like. 25–26th, snows considerable; some sleighing. December 17–18, moderate snows; sleighing.

1834.—January 1, great sleigh ride. 18th, snow gone. February 7, snow all day. April 1, snows violently. 11–17th, extremely warm. October 7, brilliant rainbow in the northwest just after sunrise. 26th, p. m., heavy shower. 31st, snowed several hours. December 13, snows. 14th, more violent snowing. 15th, the thermometer said to be 18½° below zero. 24th and 25th, more snow and sleighing. 29th and 30th, another violent snowstorm.

1835.—January 4, most remarkably cold; said to be 20° below zero. 14th, sleighing gone. February 6, snows. 15–16th, tedious snowstorm; sleighing

again. March 2, very cold. 7-10th, violent snowstorms; sleighing. 19th, snow. 22d, snow, rain, hail, thunder, and lightning. 23d, sleighing continuous. 30th, snow. April 13-15, snowstorm. 25th, snow. November 23, snow and tolerable sleighing. 30th, snows all day; very cold month. December 12, snows; very cold. 17th, more so; very, very cold; temperature 14° below zero. 22d, good sleighing.

1836.—January 17-18, snowstorm. 25th and 31st, snowed. February 8, tremendous storm; roads all banked up. 17th, more snow. 26th, snow. March 10, hard rain; hard traveling; bridges carried off. 22d, snow; good sleighing till the 28th; in all about four months sleighing; many snow banks left. April 6-13, tedious snowstorms. November 3, snow. 17th, snowstorm. 25th, squally and cold.

1837.—January 1, snow and sleighing. 18th, snow. 21st-22d, hard snowstorm. 25th, very remarkable red auroras. Quiet snows and sleighing through February. March 2, great sleighing party. 19th, very cold. 22d, cold and tedious storm; trees loaded with ice. April 1, cold, frozen rain. 2d, cold. 8th, rain and thunder all day. 9-10th, hail. 16th, cold rain. May 1, ground frozen hard. 5th, rain and thunder showers all day and evening. November 14, cold, blowing snowstorm all day. 22d, snow all day. December 10, snows. 14th, severe storm. 25th, snows all day.

1838.—January 9th, snows; warm month; snows turned to rain. Sleighing in February. March 8, heavy snowstorm. 15th, snowstorm. 27-29th, snowed and melted. April 14, snowstorm; cold and snowy to 24th. October, 28-29th, snowed moderately. November 8, hard storm; very cold. 18th, cold snowstorm. 24-25th, extreme cold. December milder, with slight snows.

1839.—January 4, snowed, but soon melted; very fine and spring like, then snow and very cold; temperature 11° below zero. 26th, violent southeast rainstorm; variable season. February 9, snow. April, dry and warm early in month. 12-18th, cold storm, rain and snow. Autumn mild. December 15, tremendous snowstorm. 16th, wind increased all day; snow very deep; fine day followed, but roads impassable. 23d, another violent snowstorm. 27th, snowed again. The amount of snow falling in these incessant storms exceeded anything reported by the oldest inhabitant; business and social intercourse were virtually suspended, and the roads were so heavily packed that it seemed impossible to force a passage. A pamphlet published in Boston tells of the "awful calamities" occurring during the "dreadful hurricanes" on December 15, 21, and 27, with great loss of life and destruction of property.

1840.—Began very cold. January 11, snows all day. 13th, snow; a day made memorable by the burning of the steamer *Lexington* on its passage from Stonington to New York. February 4, 5, extremely cold. 16th, family resumed church-going; sunny and mild days followed; the snow passed off without damage. 20th, snow nearly gone. March 4, very warm, with thunder. 6-16th, cold, high winds. 15th, snow. 22d, very cold. 24-25th, snowstorm. April 1, snow. November 15, 18, 26, reported snowfalls. December 17, 18, snow; very cold; cold weather; snows and sleighing continued through the month.

1840-1852.—During this period the journal lapses. Records from 1852 to recent date will be furnished hereafter.

LUNAR HALOS.

Dr. J. R. Finney, voluntary observer at Fort Berthold, N. Dak., gives the following description of a lunar halo seen on the night of February 11, 1894, as a remarkable example of compound halo:

The whole sky was covered for a few minutes. The phenomenon appeared at 8.50 p. m., and for twelve minutes was very distinct; a large number of luminous circles and "mock moons" were plainly visible, but three circles and eleven "mock moons" were very bright and prominent, the rest being easily traced but not very distinct. There was no wind; the temperature was -16° ; and the moon was about 11° above the horizon. Large distinct crosses were formed which gave the sky a wonderfully unique and beautiful appearance.

This phenomenon grew very indistinct at the end of twelve minutes, and at the end of half an hour only three paraselenæ and two circles could be detected. These disappeared at the end of fifty minutes.

As the diagram forwarded by Dr. Finney can not be reproduced, it may be described as representing that a large portion of the sky was covered at regular intervals, systematically, by small crosses of horizontal and vertical rays intersecting at a corresponding bright spot, or "mock moon;" these spots were about 22° apart, horizontally and vertically, and therefore represent the intersections of circles of 22° radius; the principal circles had their centers at the moon and in the horizontal circle passing through that luminary, while the others were vertically above these. Twenty such bright spots arranged in four horizontal rows, of five each, are shown on Dr. Finney's diagram.

The observer at Oil City, Pa., noted that on February 21, 10 p. m.:

High toward the zenith in the east, a huge cross, white in color and indescribably brilliant, blazed in the sky, while the moon, encircled by a similar light, made a beautiful center piece. At each corner of the cross appeared to be huge balls of living fire of all colors of the rainbow. The phenomenon lasted for nearly half an hour.

POGONIP.

The "Pogonip" is described in the "American Meteorological Journal," Vol. iv, p. 105, and in the "Annual Report of the Nevada State Weather Service" for the year 1892. It is an Indian word, applied to a mist of ice crystals or frozen fog particles that occurs most frequently in the southeastern part of White Pine County, Nevada. Many sections of the State are entirely free from the "pogonip." In Mr. Friend's report, above quoted, the phenomenon is said to be caused by the mixture of warm air from the valley rising up into a cold wind that is generally blowing lengthwise in the valley; the freezing fog descends and clothes every thing with minute frost crystals. A "pogonip" at Winnemucca, in January, 1892, lasted from the 22d to the 25th, and deposited a coating of ice needles to a depth of two inches upon trees, bushes, fences, buildings, men, and cattle. In Virginia City the observer, being generally above this layer of mist, states that—

It came suddenly; appeared in its greatest beauty on the morning of January 22; filled up the valleys and rolled up the mountain sides, leaving the tops of the largest hills like islands and rocky headlands; its waves tumbled over each other and rolled over its shores; late in the afternoon its surface was much agitated by some unknown impulse causing its great waves to roll to the westward; they took on a yellow hue, where they tumbled over the eastern mountain rim of the city; Sugar Loaf Mountain became a cone-shaped island, with falls on each side of it. The canyons were slowly filled and the vapor surged up the sides of Mount Davidson, partly covering the city, and causing intense cold where there had been sunshine and warmth before. It soon receded to its first situation, where it remained until broken up after four days of beautiful existence.

By referring to the daily maps and to the REVIEW for January, 1892, we perceive that at this time Nevada was under the influence of the area of high pressure No. VIII, whose central highest was northeast of Virginia City; there was a gentle flow of cold upper air westward and southwestward over the plateau region and this air was apparently slowly descending and cooling by the local radiation that is facilitated by its dryness and clearness. When the air near the ground is quiet it cools below its dew point and thus forms an icy fog, or "pogonip," that is colder than the layer immediately above it, not only during the nighttime, but especially in the daytime, when the upper surface of the fog stops all the heat from the sun.

Similar cases of such cooling and ice mist are occasionally observed at many other places, and probably they occur very generally whenever at sunrise a cold, thin mist prevails near the earth's surface; in such cases for several hours after sunrise the temperature near the surface of the earth still remains very low; there seems to be no warmth in the sun's rays until after their heat has entirely dissipated the thin haze of frozen fog.

Thus, at Washington, D. C., November 19, 1891, after a cloudless night, the air being very dry, cold, frosty, and calm in the center of a high area, a mist had formed about 8 a. m., increasing to a high haze, and up to 10 a. m. there was still no heat in the sun's rays. On a foggy or hazy summer morning the low-down sun is warm, but not so this morning. The moisture in the air was probably now in the shape of crystals or spherules of ice, the sun's heat was being used up in melting this ice, and, therefore, it did not warm the air above us, much less that near the ground; after melting the ice the solar heat must warm and evaporate the resulting water, and the air can attain only to the temperature of the wet bulb until all is vaporized. During the nighttime the still air had allowed much ice in the form of small particles to form in the atmosphere and settle down near the ground, so that at 8 a. m. the lower stratum of air contained much more to be

melted and evaporated than it did at the previous sunset, and much more than the stratum just above it. Therefore, this morning the lower air was more hazy than on the 18th and the cold lasted longer after sunrise; only after the lower air had become thoroughly warmed, and had risen and mixed with the upper air, could the haze disappear and the normal temperature and dryness return. The frost work in high winds on mountain tops apparently differs from that of the "pogonip" and low lands mostly in that the latter is formed by radiation in still air, while the former is due to thermodynamic cooling in ascending air.

CHINOOKS AND HOT WINDS.

In striking contrast to the "pogonip" that prevailed during January 21-26, 1892, in Nevada, under the slowly descending winds from high pressure No. VIII, was a "chinook" wind that occurred a few days before, viz, on January 18 and 19, 500 miles to the northeast, in Montana, and on the northeastern side of the same area of high pressure, but where the outflowing winds from the southwest were rapidly instead of slowly descending, and were, therefore, being warmed by compression faster than they could be cooled by radiation.

In September, 1890, and as a suggested reply to a letter from Senator Plumb, of Kansas, relative to an investigation of the hot winds of that State, the present editor used the following language:

These winds affect a large part of the country east of the Rocky Mountains, and are not peculiar to Kansas. * * * With regard to the cause and origin of the hot winds the following statement is the best that I am at present able to give:

With clear, dry air we usually have hot days and cool nights, but during the hot winds of Kansas the nights are frequently nearly as hot as the days; the hot winds frequently begin at night and blow continuously day and night. The fact that they blow from the south naturally suggests that they consist simply of hot surface air from northern Texas; but as the air seems to grow hotter as it flows northward from Texas, and as there are very few cumulus clouds in this air, notwithstanding the fact that it is rising slowly, it has been concluded that there must be some descending dry, warm air mixing with the ascending hot surface stream, and thus preventing the production of cloud. Now the descent of air warms it up, as in the föhn winds of Switzerland, so that a slowly descending layer of air over Kansas may contribute several degrees to the warmth and much to the dryness of the air. This descending air may have come from the Pacific coast over Mexico or California, or British Columbia; either is possible, the latter more likely, and the fact that July, 1890, shows a surplus of rain on the Pacific coast is entirely consistent with the excessive heat that occurred in Kansas and Nebraska, as shown on the charts in the WEATHER REVIEW for that month.

Nothing can be done to avoid or avert these hot winds, and the direful consequences to agriculture can only be diminished by supplying an abundance of water to the roots as soon as a hot wind sets in, and by sheltering both soil and leaves, especially the latter, from the direct sun's heat; a very dry wind, or great heat without the wind, wilts the leaves by evaporating the juices faster than the roots can supply the sap.

WARM REGIONS IN CYCLONES.

Not only are the chinook, the föhn, and the hot wind of our western plains familiar illustrations of the general principle of the dynamic warming of descending air, but in general the relation between ascending and descending winds attending the movement of successive cyclonic and anticyclonic areas over the United States is such that south and southwest of the area of lowest pressure, in the region where the rare and light air of the southwest winds is about to be succeeded by the denser and heavier air of northwest winds, we find in many cases a rather long and narrow region separating these two winds, and within which there temporarily prevails clear sky, higher temperatures, light winds or calms. This region, which over the land is usually elongated northward and southward, and is probably influenced somewhat by local topography, corresponds closely if not exactly to the so-called "eye" of the storm in tropical hurricanes; they both owe their existence to the same mechanical processes, so that the difficulties that have been felt by some in explaining the mechanism of the eye of the storm disappear when we come to consider the phenomenon experienced in

ordinary land storms. The region of temporary clearing away of the clouds, with the hot, moist, sultry air and light winds, is sometimes very strongly marked to observers at Washington, and, in fact, along the entire eastern slope of the Appalachians, but as it has also been observed by me on the western slope of this range, I conclude that the mountain ranges and local topography play only a minor part in accentuating some features of the mechanism. Many typical cases of this phenomenon have been noted by me at Washington, but the most striking one seems to have been the severe storm of November 23, 1891.

The following notes were made by me, and the times, as given by my watch, are probably correct within two minutes. Up to 12.30 p. m. there was a surface wind and lower clouds, small cumuli, from the southeast; above this a blue sky, except for some high cirrus clouds moving from the southwest. At 12.32 a rain gust began at the Weather Bureau, with southeast wind, and from a south-southeast lower cloud. At 12.33 the lower clouds were seen to be changing their motion and coming from the south, while a denser low cloud was visible to the westward, rapidly approaching; it arrived within a minute; the surface wind suddenly blew violently from the south and then from the southwest; the rain changed to snow and was carried northeastward aloft, visibly over the southeast wind; the barometer suddenly rose. At 12.43 clear sky was visible in the southwest beyond the cloud; shortly afterward this cloud bank passed entirely overhead to the eastward, and as seen then its western side presented the appearance of a ridge of towering cumuli. Clear sky and warm light winds prevailed until 3.50 p. m., then a cloud bank rose in the west and northwest, and cooler northwest winds came in; this second cloud bank was preceded by many rolls arranged in parallel rows trending northeast and southwest.

As I interpret these events, the warm, clear space that required three hours to pass over the observer represented the region in which that general downpour of air was going on, by means of which the area of opposing southeast wind was being pushed eastward by the following northwest wind; the first cloud bank represented the front edge of this downpour where the southeast wind was pushed up and to a slight extent mixed with the incoming wind, but eventually made to flow over on itself toward the northeast; the high cirri seen at 12.30 above the smaller cumuli, and which were trending and moving toward the northeast, represented this overflow. We may thus characterize the entire system of circulation as follows:

A. On the eastern side of the first cloud bank we have a lower southeast wind, in which small cumuli are formed at some distance from the cloud bank, and others of larger size as we approach the latter, which, in fact, towers up at *B* to the greatest height, and overflows as cirrus, *C*, toward the northeast, thinning out into dissolving cirri as it flows onward.

D. On the western side of the cloud bank, and at this time 50 or 100 miles away, we have at the surface of the ground a northwest wind rolling up; as it advances southeastward down the general slope of the Appalachians it is forming small cumuli, *E*, that overflow from the southwest.

F. The broad interval between *B* and *E* is filled principally with the overflow from the latter; each portion of the northwest wind that is pushed up by the many irregularities of the earth's surface over which it has to flow, becomes in its turn an overflow and veers from a northwest wind below to a southwest wind above; these upper overflows from *E* slide rapidly down along surfaces of equal density until they reach the ground, where they either rest quietly or continue flowing gently from the southwest; therefore, geographically speaking, the region *F* precedes the region, *D*, of northwest winds and is cloudless and warm.

The upper portion of the region, *F*, just described is at the level of the top of the cirri, *C*, in the overflow region above *A*, so that both *C* and *F* flow on together from the southwest to northeast.

The shape and dimensions of the warm, clear region, *F*, and its location with reference to the isobars, depend not only on the topography of the ground, but also especially on the general characteristics as to temperature, moisture, and pressure within each of the two systems of wind; we have at one extreme a long, narrow area dividing southeasterly from northwesterly winds, in which case the clear, warm region is correspondingly long and narrow, or V-shaped; or we may have a symmetrical cyclonic arrangement of the winds, with a descending overflow from the northwest wind confined to a small central region, as in the "eye" of the hurricane, which phenomenon has been observed by me on every occasion on which a hurricane center has passed over or near Washington; or, finally, and this is the more common case, the local orographic features of the land break up the surface winds into patches of northwest, southeast, etc., so that there are formed simultaneously several separate regions of warm air and clear sky between corresponding systems of winds that are more or less opposed to each other. Opposing winds will not flow toward a central region, *F*, unless, in general, some slight deficit of pressure exists therein, but when they meet and push each other upward a portion of the kinetic energy is transformed into static pressure, or the so-called potential energy. The region, *F*, of descending and warm, clear air represents this general region of lowest pressure, and the formation of the heavy cloud bank, *B*, is attended by a sudden increase of pressure at the earth's surface, notwithstanding the fact that at the base of and within the cloud there may be an upward current and a diminution of pressure. Such a sudden increase of static pressure is frequently shown by self-registering barometers, and must always occur when the motion of a rapid current of air is suddenly checked by an opposing current or by the earth's surface.

THE AURORA POLARIS.

The extensive aurora of the 22d and 23d has necessitated a consideration of the many diverse views that have been expressed as to the nature of this phenomenon and its bearing on meteorology. The editor, therefore, submits his conclusion that this must not be considered as an electric display high above the clouds of the earth's atmosphere and rendered visible by the clear sky attending an area of high pressure, but on the contrary as a display whose seat or locus was in the lower atmosphere near at hand, sometimes below the clouds, and whose very occurrence depended upon the existence of an area of dry and cold air overlaid by a moister atmosphere, in which a slight condensation of vapor was going on. As condensation into hail and rain attends lightning, so condensation into snow crystals is attended by broad but silent flashes, and the condensation into a delicate haze of ice spiculæ accompanies the aurora. The atmosphere and its moisture are always in an electrified condition and preparing for an electrical discharge, but the nature of the discharge will depend upon the condition of the air as to temperature, humidity, and possibly dust and barometric pressure.

In 1872, in connection with the notable aurora of February 4 (see Bull. Phil. Soc., Wash., Vol. 1, p. 45), the present writer stated that the aurora stands in an intimate relation to the condition of the earth's atmosphere; that, in fact, although the ultimate cause of the electrified condition of the earth and its atmosphere may be ever acting, may be cosmical or solar, and may, therefore, be subject to periods of one, or eleven, or fifty-five years, yet, on the other hand, that electricity can not produce its visible effect, the aurora, except in certain conditions of the earth's atmosphere and that, therefore, certain remarkable relations exist between auroral

phenomena and terrestrial storms, some of the details of which he then briefly indicated. In connection with the aurora of April 6, 1874, it was shown that the display emanated from a very low and not an elevated region. In editing the appendices to Professional Paper No. III, of the Signal Service, I inserted the data as to the frequency of clear or cloudy nights alongside of the data as to frequency of auroras, in order that the relation between these two meteorological phenomena might be more completely elucidated. The statistics show that it is unreasonable to assume that the aurora is often above but hidden by the clouds and more reasonable to conclude that for each station there is no aurora at all unless the sky is clear or clearing away as to the lower clouds; the presence or formation of thin haze is more likely to accompany than to prevent auroras. The special cases there quoted of instances wherein auroral light has been observed quite close to the observer have since then been supplemented by several additional cases of a similar character. It is important to bear in mind these general conclusions as to the very low altitude of the auroral light, in order that our meteorological data may be properly brought to bear on the study of auroral data, such as presented in the monthly tables of the REVIEW. The interpretation by general statistical methods of such masses of rather crude data as the auroral reports usually afford is not likely to lead us to the unknown laws of nature until we have attained some knowledge as to the origin of the phenomena and the real physical connection between them.

The present aurora appears to have had an intimate connection with an area of high pressure and clear air that extended northward beyond our stations and had brought from distant regions such a condition as to temperature, moisture, and electricity that it was doubtless possible for the auroral discharge to continuously take place night and day in its northern and central portions, but in the southern portions, although the electrified vapor was present in the layer whence the aurora emanated, yet the temperature needed to be still further lowered a little by nocturnal radiation. The electric equilibrium of the atmosphere when seriously disturbed is soon restored by a few discharges; it is only when the disturbance is perpetually renewed that the discharges become correspondingly frequent; the slight electrical disturbance possibly produced in the atmosphere during the daytime of the 21st, 22d, and 23d over the auroral region, conjoined with the greater disturbance brought into this region by the area of high pressure, was relieved by the auroral discharge within a few hours on the evenings of the 22d and 23d as soon as the nocturnal radiation had brought the atmosphere into the proper condition for the formation of ice spiculæ.

This radiation goes on simultaneously, but the necessary result is attained later in the evening at some stations than at others. This general retardation results from the fact that both the atmosphere and the soil at the southern stations are warmer than at the northern; moreover, on account of the snow lying on the ground the nocturnal radiation from the surface into the air is greater at the southern stations, so that for both reasons the southern stations require a greater time for the lower air to cool. For the same reason as well as because of the excess of moisture and the retardation due to the mixture of the wind, the layer that finally reaches the necessary temperature and humidity is higher up at the southern than at northern stations. This accords with the general observation that the display of the 22d seems to have taken place comparatively high in the atmosphere over the Pacific States, and that of the 23d comparatively high at the southern and eastern boundary of auroral visibility, but both appeared always lower down and with many more details as to motions and beams, curtains and waves, arches and colors in the dry regions of the central portions of the area of high pressure.